

UNITED STATES PATENT OFFICE

2,645,568

JET FUEL CONTAINING t-BUTYL
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2 Claims. (Cl. 44-63)

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This invention is directed to improved fuels utilizable in jet combustion devices. It is particularly directed to jet combustion fuels having improved jet combustion properties through the addition thereto of small amounts of an additive material.

The simplest form of jet combustion mechanism is a tube with one end closed, in which a combustible is burned. The expanding gases of combustion issuing from the open end of the tube give rise to a reaction effect which drives the tube in a direction opposite to that of the emission of the gases. The most complicated forms presently proposed consist of the same propulsion or jet tube, plus a compressor to supply air for combustion, plus a gas turbine which extracts enough energy from the departing gases to drive the compressor. In present commercial forms, the compressor and turbine are assembled axially upon a common shaft, spaced far enough apart to permit a number of combustion chambers to be arranged about the shaft between the compressor and turbine with an exhaust tube extending rearwardly from the turbine. In essence, the term jet combustion, as now commonly applied, and as used in this specification, refers to a method of combustion wherein fuel is continuously introduced into and continuously burned in a confined space for the purpose of deriving power directly from the hot products of combustion.

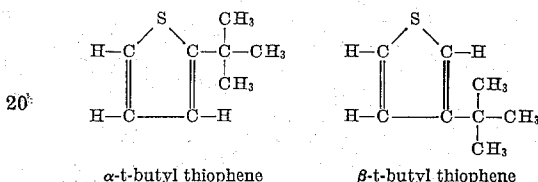
In practice, the range of conditions over which a jet combustion device may operate may become quite limited for ill-chosen or ill-adapted fuels. Even though a combustible mixture be present, the flame will be blown out if the rate of fuel feed is too far increased. Yet, high rates of fuel feed are necessary to obtain high heat release, which is high power delivery. Fuels with low blow-out levels can furnish only limited power and limited flexibility under conditions of operation. Consequently the flame stability of a fuel is of major importance.

It has been found that flame stability of a fuel is correlated with a property of the fuel which is readily reproducible on a laboratory basis, using apparatus which is simple when compared to a commercial combustion tube, and with considerably less procedural difficulty. This correlated property is the rate of flame propagation as measured in a Bunsen-type burner, using the method of Smith and Pickering (J. Res. Natl. Bur. Stds. 17, 7 (1936)). In this procedure, the rate of flame propagation is measured at a number of fuel-air ratios by photographing the flame and measuring the slope of the flame cone.

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Desirable levels of commercial operability may be found in fuels having rates of flame propagation of the order of 1.4 feet per second and higher. Benzol, an excellent fuel, has a rate of flame propagation of about 1.6 feet per second, at a fuel mixture temperature of 230° F., a pressure of 1 atmosphere, and an air flow rate of 3.15 pounds/hour.

The present invention is predicated upon the discovery that small amounts of α -t-butyl thiophene or of B-t-butyl thiophene or of mixtures of α - and B-t-butyl thiophenes, when added to a fuel, will materially improve the combustion stability thereof. These butyl thiophenes have the following structural formulae:



These compounds are readily produced in accordance with known methods of the prior art. In general, in accordance with prior art processes, thiophene is alkylated with suitable alkylating agents, such as olefins and alcohols, in the presence of alkylating agents, such as sulfuric acid, dihydroxyfluoboric acid, aluminum chloride, boron trifluoride, phosphoric acid, and alumina-silica-type catalysts (Kutz et al., Journal of the American Chemical Society, 68, 1477; and Caesar, Journal of the American Chemical Society, 70, 3623 (1948)). In accordance with these processes of the prior art, when thiophene is alkylated with t-butyl alcohol, in the presence of an alumina-silica-type catalyst, the reaction product is a mixture of about 70% α -t-butyl thiophene and about 30% B-t-butyl thiophene.

In the practice of the present invention, the amount of additive (t-butyl thiophenes) used falls within the range varying between about 0.1% and about 2.0% by weight. Greater amounts, up to 10%, may be used if desired, although, in general, no outstanding results seem to occur. Conceivably and within the scope of the present invention, the jet fuel additives contemplated herein may be marketed or procured as concentrates, viz., jet combustion fuels containing upwards of 10% and up to 49% by weight of the additives. These concentrates are subsequently added to a jet combustion fuel in such proportions as to produce the effective concentration of additive in the fuel desired, i. e., a

sufficient amount to improve the jet combustion properties of the jet combustion fuel.

The jet combustion fuels of the present invention may contain other materials or additives for improving other characteristics thereof. Carbon deposition-reducing additives, gum inhibitors, and starting aids are mentioned by way of non-limiting examples of other additives which may be present in the jet combustion fuels of the present invention.

The addition of α - or of B-t-butyl thiophene or of mixtures thereof may be made to fuels of a fairly wide variety of boiling ranges, specific gravity, etc. Suitable base fuels for use in accordance with this invention include those having the character of light gasolines up to those having the character of gas oils; synthetic fuels, such as those manufactured by the Fischer-Tropsch process, can be used, as can be fuels derived from coal or wood distillation. It is also contemplated to add these combustion improving additives to liquid alcohols or combinations of alcohols and other base fuels. The preferred fuel is, however, a hydrocarbon distillate fuel boiling within the range of about 100° F. to about 600° F.

The physical characteristics of a few examples of suitable base fuels are given hereinafter for illustrative purposes:

1. Hydrocarbon distillate fuel—

Boiling range	105–535° F.
Gravity	53° A. P. I.
Vapor pressure	5.4 Reid, pounds.
Freezing point	Below –76° F.
Sulfur	0.03%, by weight.
Bromine No	15
Aromatics	15% by volume.
Viscosity	.773 centistokes, at 100° F.
2. Reference fuel—

Boiling range	205–225° F.
Gravity	71.6° A. P. I.
Vapor pressure	1.7 Reid, pounds.
Freezing point	Below –76° F.
Sulfur	0
Bromine No	0
Aromatics	0
Viscosity	.623 centistokes, at 100° F.
3. Hydrocarbon distillate fuel—

Boiling range	320–470° F.
Gravity	36.5° A. P. I.
Freezing point	Below –76° F.
Sulfur	0.035% by weight.
Bromine No	1
Aromatics	12.1% by volume.
Viscosity	1.48 centistokes, at 100° F.

The following examples are given for the purpose of illustrating the present invention and for indicating the advantages thereof. It must be clearly understood, however, that these examples

are non-limiting. It will be appreciated by those skilled in the art that numerous types of jet combustion fuels, other than the standard reference fuel described hereinafter, may be used for the purpose contemplated herein.

In these tests a reference fuel was used which was substantially 2,2,4-trimethylpentane, commonly known as S-reference fuel. The rate of flame propagation using the standard reference fuel was compared with that of a blend of the S-reference fuel with a mixture of 0.5% of α -t-butyl thiophene plus B-t-butyl thiophene, in accordance with the procedure of Smith and Pickering referred to hereinbefore. In these tests, the additive was a mixture of 60% α -t-butyl thiophene with 40% B-t-butyl thiophene. The fuel mixture was maintained at a temperature of about 230° F.; under a pressure of 1 atmosphere, and the air flow rate was controlled at 3.15 pounds/hour.

Table

	Rate of flame propagation
100% reference fuel	1.45 ft./sec.
99.5% reference fuel	
0.5% of mixture of α with B-t-butyl thiophene	1.53 ft./sec.

It will be seen that by adding as little as 0.5% of the additive material to the fuel, an increase of over 5% in rate of flame propagation can be obtained, which, as indicated hereinbefore, means a substantial improvement in combustion stability.

This application is a continuation-in-part of the copending application, Serial No. 746,325, filed on May 6, 1947, now abandoned.

I claim:

1. A liquid capable of being utilized as a fuel in jet combustion mechanisms, which consists essentially of a hydrocarbon distillate having an initial boiling point of about 100° F. and a final boiling point of about 600° F. and boiling substantially continuously between said points, and between about 0.1% and about 10.0% by weight of a t-butyl thiophene.
2. A liquid capable of being utilized as a fuel in jet combustion mechanisms, which consists essentially of a hydrocarbon distillate having an initial boiling point of about 100° F. and a final boiling point of about 600° F. and boiling substantially continuously between said points, and between about 0.1% and about 10.0% by weight of a mixture of α -t-butyl thiophene with β -t-butyl thiophene.

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